NetSciX2026: International School and Conference on Network Science
February 17th-20th, 2026 - Auckland, New Zealand

Applicability of the Minimal Dominating Set for Influence Maximisation in Multilayer Networks

Influence Maximisation, Minimal Dominating Set, Multilayer Networks, Network Control

Introduction

The minimal dominating set (MDS) is a well-established concept in network controllability, with successful applications in various areas [1]. This study examines its potential to improve seed selection strategies for influence maximisation (IM) [2] in multilayer networks (MLNs), aiming to bridge control theory with social influence. While this approach has proven effective in single-layer networks [3], its performance in MLNs remains unexamined.

Methodology

The MDS is a non-reducible set of "driver agents" capable of controlling the network. A set of actors D' dominates the MLN if, for every actor a, either a belongs to D' or, for each layer where a is represented, the corresponding node of a is adjacent to a node that represents an actor in D'. An MDS (D) is a dominating set whose size cannot be further reduced (Fig. 1).

We apply the Multilayer Linear Threshold Model to simulate actor-based diffusion, which is based on two thresholds: intra-layer μ from the classic LTM, and δ (the protocol), which aggregates inputs across layers per actor. If the protocol threshold is exceeded, the actor and all its nodes activate; otherwise, it remains inactive, even if some of the corresponding nodes in the layers received positive input. We study two protocols: *AND*, requiring activation in all layers, and *OR*, requiring it in any layer. We also explore a range of seed set budgets (s).

Five rank-refining seed selection methods [2] are used to assess the effectiveness of MDS in IM. Each is augmented with an additional step that filters out actors outside the MDS, ensuring only dominating actors are eligible as seeds. This enables a direct comparison between the original and MDS-backed version of each method. Tests are conducted on Erdős-Rényi (ER), Scale-free (SF), and real-world networks. Diffusion effectiveness is measured using a gain metric ($\Gamma \in [0,1] : \uparrow$), based on total activations relative to the seed set size.

Results and Conclusions

The analysis of the MDS incorporation shows that it substantially alters seed sets, which share on average a 36% similarity with those obtained by their baseline counterparts.

The most promising diffusion boost is obtained for protocol *AND* (Fig. 2). Six parameters are analysed, as described in the figure caption, with the key metrics being the mean $\Delta\Gamma$ between baseline and MDS-backed methods, and the percentage of experiments where MDS significantly improves spreading. The latter persists across all network types when spreading relies on a low threshold and larger seed budgets. Regarding $\Delta\Gamma$, the greatest improvement is observed in SF networks, with diffusion boosted by up to 0.26. ER networks show more moderate gains, while real-world networks exhibit intermediate results between these models.

In conclusion, our findings reveal that incorporating MDS into the seed selection process improves spread only under specific conditions: i.e., for larger seed set budgets, lower activation thresholds, and when an *AND* strategy aggregates influence across layers. In other words, if one seeks to persuade a wide audience, particularly those whose conviction is easily swayed but must be convinced across all their social circles, starting from the MDS is a good choice.

Although this work remains theoretical, some ethical issues arise. These relate to the IM problem, as the results could be misused to manipulate social systems. However, publishing the outcomes promotes transparency and helps prevent their application for harmful purposes.

References

[1] J. C. Nacher and T. Akutsu. "Dominating SF networks with variable scaling exponent: heterogeneous networks are not difficult to control". In: *New J. of Physics* 14.7 (2012).

[2] S. S. Singh et al. "IM frameworks, performance, challenges and directions on social network: A theoretical study". In: *J. of KSU — Computer and Information Sci.* 34.9 (2022).

[3] Abida Sadaf et al. "A bridge between influence models and control methods". In: *Applied Network Science* 9.1 (2024).

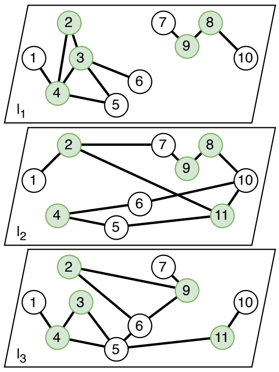

Figure 1: An example of a MLN with three types of relations (l_1, l_2, l_3). Nodes representing actors that belong to the MDS are highlighted in green ($D = a_2, a_3, a_4, a_8, a_9, a_{11}$).

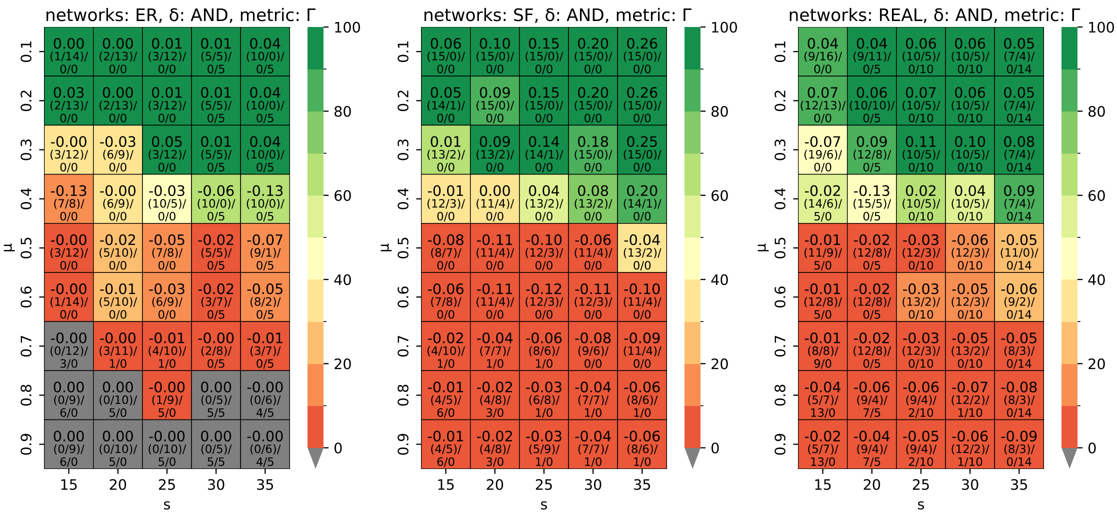

Figure 2: Improvement of MDS filtering across network types and spreading regimes, measured with Γ. Each tile shows six values: the **upper value** is the mean difference between the baseline and MDS-filtered variant ($\Delta\Gamma \in [-1, 1]$) across feasible experiments; the **middle row** presents the count of feasible experiments, split into those with a difference greater (**left**) or less than/equal to 0.01 (**right**); the **lower row** shows unfeasible experiments where diffusion couldn't start (due to an overly strict spreading regime, **left**) or where $|\hat{D}| < s$ (**right**). The **colour** represents the percentage of feasible simulations where the MDS-filtered variant outperformed the baseline, computed over feasible simulations with an absolute difference > 0.01.